then undergoes 90 degrees polarization rotation in the double pass through $\lambda/4$ waveplate **106** (mirrors **108** are highly reflective mirrors). After a second amplification pass through the Nd:YAG rod, the now S polarized beam reflects off PBS **98**, the two mirrors as shown and PBS **100** for two more amplification passes through the second rod. The amplified beam is doubled to 532 nm from 1064 by a KTP nonlinear crystal **112**. We obtain 55 percent conversion to the green (**532**). The residual 1064 nm is reflected off dichroic mirror **110** to an absorbing surface (dump) **114** while the 532 nm is transmitted through the dichroic mirror. The beam is then focused by a best form lens **116** (5 cm focal length) onto a 10 micron diameter spot on metallic target **118** which rotates by means of a stepper motor. The target is enclosed in a hermetically sealed chamber that was evacuated to vacuum and filled with helium gas to 600 torr. The X-ray output is detected by an X-ray diode **120** that was calibrated to IBM standards for X-ray lithography. The above described system is capable of operating at 10 Hz maximum due to the repetition rate limitation of the flash amplifier. The seed laser alone can exceed a repetition rate of 1 kHz. We have demonstrated X-ray (1 to 1.5 nm wavelength) conversion efficiency into $2\pi$ steradian of about 7 percent in stainless steel and about 3.5 in copper. FIG. **11** shows the experimental data from a copper target, with a promising trend toward higher efficiencies at higher pulse energies. At 1064 nm we were able to increase the energy per pulse to over 250 mJ/p without any damage to the system, and with the proper doubling, we should be able to increase the 532 nm beam to near 130 mJ/p. As indicated above with respect to the above described embodiments, future systems will have pulse rates far greater than the 10 Hz of this experimental system.

While the above description contains many specificities, the reader should not construe these as limitations on the scope of the invention, but merely as exemplifications of preferred embodiments thereof. Those skilled in the art will envision many other possible variations which are within its scope.

For example, with the first preferred seed laser, we could choose a much shorter pulse duration than 100 ps. These could be obtained using a passive saturable absorber instead of the acousto-optic mode locker. With a saturable absorber we can get femtosecond pulses. It is our belief that the advantage of pulses in the 100 ps range is that we get some heating of the plasma whereas the very very short pulses creates the plasma but provides very little heating of it. The energy per pulse needs to be in the range of 80 mJ/pulse (or more) when the objective lens is about 12 cm from the target. A distance of at least 12 cm is recommended to avoid contaminating the lens with target material. However, if this distance is reduced the required energy per pulse could be reduced accordingly because we could focus on a smaller spot. By doing so we could reduce the energy per pulse requirement from about 80 mJ/pulse to as low as about 10 mJ/pulse.

A prepulse configuration can be used to further improve the x-ray production. A first laser pulse hits the target to generate plasma and the major laser pulse then hits the same spot on the target a short time thereafter to further heat the plasma for efficient x-ray generation.

The cost of laser diodes for pumping solid state lasers is primarily dominated by the peak power requirements and this determines the number of diode bars. By operating the bars at a relatively high duty factor of 20 percent and generating a large number of pulses per second, we can minimize the initial cost of the diode pumping system. For example, a 1 kW system may require 3 kW average power from the pump diodes, a 20 percent duty factor diode array system would require 15 kW peak power. Using 50 Watt peak bars at $700 per bar, the system would cost $210,000. In comparison, a 1 percent duty factor system would require 300 kW peak power. The cost would be $4,000,000. Increasing the duty factor above 20 percent, all the way to CW is feasible, but, balancing all factors (including system lifetime and complexity), we prefer a duty factor of about 20 percent. Persons skilled in the art will recognize that a flash lamp pumping system could replace the diode pumping system.

The solid state material can be a host of materials other than Nd:YAG. For example, Nd:YLF, Cr:LiSAF, Ti:S, etc could be used. Amplification needed to boost the seed beam to the mJ/pulse level can be satisfied by either high gain or multiple passes. Up to eight passes can be achieved with passive components and much higher number of passes can be achieved in a regenerative amplifier. The steering mirror can be any reflecting element that would would be appropriate to generate the cluster of spot sizes desired, such as the 20 μm spots.

The first preferred seed beam pulse train frequency could be in the range of 10 MHz to 200 MHz or greater. With some compromise in the average power the number of pulses per second could be reduced down to about 1,000 Hz.

The amplifier can be of slab or rod design. The solid state material can be of a host material other than Nd:YAG. For example, Nd:YLF, Cr:LiSAF, Ti:S, etc. could be used. Amplification needed to boost the seed beam to the mJ/pulse level can be satisfied by either high gain or multiple passes. Up to eight passes can be done with passive components and much higher number of passes can be done in a regenerative amplifier. The steering mirror in the amplifier can be any reflecting element that would be appropriate to generate the cluster of spot sizes desired, such as the 20 μm spots.

With respect to the first preferred embodiment, other devices could be substituted for the electro-optic modulator for pulse spacing, such as cavity dumping or even an optical rotary interrupter. The pulse spacing devices would in most applications remove a very large percentage of the pulses in the first preferred seed beam such as more than 99 percent as in the preferred embodiment described; however, We could imagine applications where as the percentage remove might be as low as 80 percent. In addition to the low debris generation in a picosecond pulse system, it is also possible to have the target chamber in atmospheric helium without breakdown of the helium (the breakdown is a strong function of the pulse duration), which simplifies the X-ray transmission window to the outside world, and further reduces contamination by the debris off the target.

In addition to X-ray lithography there are several other potential applications for the system described in this disclosure such as X-ray microscopy, biological / radio biological, micro electromechanical system fabrication, bright X-ray source to replace conventional electro-bombardment sources, cell and DNA X-ray crystallography, X-ray fluorescence for material contamination detection, laser ablation technology and more.

Accordingly the reader is requested to determine the scope of the invention by the appended claims and their legal equivalents, and not by the given examples.

We claim:

**1.** A high average power, high brightness solid state pulse laser system comprising:

a) a seed laser subsystem means for producing a first pulse laser beam with a pulse frequency in excess of 1,000 pulses per second each pulse having a duration of less than 1 ns,